CLAIMS

What is claimed is:

1. A method for plasma treating an exposed copper surface and dielectric insulating layer in a semiconductor device manufacturing process comprising the steps of:

providing a semiconductor wafer comprising a process surface having an exposed copper portion and an exposed dielectric insulating layer portion;

plasma treating the process surface in a first plasma treatment with plasma comprising reduction gas and nitriding gas; and,

plasma treating the process surface in a second plasma treatment with comprising oxidizing gas.

2. The method of claim 1, further including the step of pre-heating the process surface to a temperature of between about 200°C and 350°C prior to the first plasma treatment process.

3. The method of claim 1, wherein the reduction gas comprises NH_3 and H_2.

4. The method of claim 1, wherein the nitriding gas comprises N_2, N_2O and NH_3.

5. The method of claim 1, wherein the first plasma treatment comprises a plasma gas source comprising an reduction gas to nitriding gas ratio between about 1 to 5 and about 1 to 60.

6. The method of claim 1, wherein the second plasma treatment comprises a plasma gas source comprising O_2 and at least one of O_3, CO, CO_2, NO, and N_2O.

7. The method of claim 1, wherein the second plasma treatment comprises a plasma gas source consisting essentially of O_2.

8. The method of claim 1, wherein the dielectric insulating layer comprises porous low-k material.

9. The method of claim 8, wherein the dielectric insulating layer comprises a dielectric constant of between about 2.2 and about 3.0.

10. The method of claim 1, further comprising the step of blanket depositing an etch stop layer of an in-situ PECVD process with respect to at least the second plasma treatment.

11. The method of claim 10, wherein the etch stop layer is selected from the group consisting of silicon nitride, silicon oxynitride, titanium nitride, silicon carbide, and silicon oxycarbide.

12. The method of claim 1, wherein the second plasma treatment is carried out in-situ with respect to the first plasma treatment.

13. The method of claim 1, wherein the first and second plasma treatments are carried out at a pressure between about 1 milliTorr and about 10 Torr.

14. A method for plasma treating a copper interconnect and low-K IMD layer in a semiconductor device manufacturing process comprising the steps of:

providing a semiconductor wafer comprising a copper interconnect formed in an IMD layer comprising porous low-k having a process surface comprising an exposed copper portion and an exposed IMD layer portion;

plasma treating the process surface in a first plasma treatment process with plasma comprising ammonia (NH_3) and nitrogen (N_2);

plasma treating the process surface in a second plasma treatment process with plasma comprising oxygen (O_2); and,

depositing an etch stop layer over the process surface in a PECVD process.

15. The method of claim 14, further including the step of pre-heating the process surface to a temperature of about 200°C to about 350°C prior to the first plasma treatment process.

16. The method of claim 14, wherein the first plasma treatment comprises a plasma gas source comprising an ammonia (NH_3) to nitrogen (N_2) ratio between about 1 to 5 and about 1 to 60.

17. The method of claim 14, wherein the second plasma treatment comprises a plasma gas source comprising O_2 and at least one of O_3, CO, CO_2, NO, and N_2O.

18. The method of claim 14, wherein the second plasma treatment comprises a plasma gas source consisting essentially of O_2.

19. The method of claim 14, wherein the IMD layer comprises a dielectric constant of between about 2.2 and about 3.0.

20. The method of claim 14, wherein the step of blanket depositing an etch stop layer is carried out in-situ with respect to the second plasma treatment.

21. The method of claim 14, wherein the etch stop layer is selected from the group consisting of silicon nitride, silicon oxynitride, titanium nitride, silicon carbide, and silicon oxycarbide.

22. The method of claim 14, wherein the second plasma treatment is carried out in-situ with respect to the first plasma treatment.